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RMRS Rocky Mountain Remediation Services, L.L.C.
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INTEROFFICE MEMORANDUM

000058542

DATE: September 11, 1995

TO: W. L. Peregoy, Risk Management Programs, Bldg. 130, X5474

FROM: W. R. Belcher, Hydrogeology Services, Bldg. 080, X6931 WRB

SUBJECT: BUILDING 371 DRAINAGE SIMULATION REPORT -WRB-007-95

DOE Order: 4700.1

Action: None

This memorandum transmits the report documenting the Building 371 Drainage System simulation. This simulation examined the effect of a catastrophic failure of the foundation drainage system and provided estimates of the water level recovery after such an event.

The document was written by W. R. Belcher (RMRS), and reviewed by several subject matter experts, including B. L. Roberts, RMRS (modeling), F. C. Grigsby, RMRS (geology), and T. P. Lovseth, RMRS (hydrogeology).

If you have any questions, please contact Wayne Belcher at extension 6931.

Enclosure
As Stated

rap

cc:
C. S. Evans
T. P. Lovseth w/o Encl.
F. C. Grigsby
ER Project File (2)

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Building 371 Drainage System Simulation
Rocky Flats Environmental Technology Site
Golden, Colorado

prepared by
Hydrogeology Services
Remediation Services Group
Environmental Restoration
Rocky Mountain Remediation Services, L.L.C.

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LIST OF FIGURES

1.0 INTRODUCTION

This report documents the modeling study of the Building 371 foundation drainage system requested by the Risk Management Programs Group (Kaiser-Hill). The purpose of this study is to provide an estimate of the time for water level recovery after a hypothetical drainage system failure at Building 371 and uses typical and average values for hydrogeologic parameters. The model is not a detailed representation of the hydrogeology around Building 371, but rather a representative simulation.

Building 371 is intended to be the primary plutonium storage facility at the Rocky Flats Environmental Technology Site (RFETS). This modeling is part of an on-going study begun in 1993 examining the feasibility of plutonium storage in Building 371. Previous work includes a seismic risk analysis, the confirmation of a probable bedrock fault near Building 371, and a trenching program to assess if capable faults exist at RFETS.

This model simulates the sub-basement and basement drainage systems constructed in the Arapahoe/Laramie Formation claystones. The model simulates a simplified version of the excavation footprint and the various geologic media beneath the building. The geologic materials present in the building vicinity include the alluvium, claystone, compacted backfill, and the drainage filter material.

2.0 CONCEPTUAL MODEL

RFETS is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver. The plant site consists of 6550 acres of federally owned land of which 6170 acres is a buffer zone surrounding an inner industrial complex (Figure 1). Building 371 is located at the northwest corner of this Industrial Area (Figure 2). The building basement and sub-basement has been excavated into the claystone bedrock, into which the drainage system has been installed.

2.1 Geology

The geology of the area around RFETS consists of surficial deposits overlying sedimentary bedrock layers. The Quaternary- to Pleistocene-aged surficial deposits consist of pediment alluvium, colluvium, valley-fill alluvium, and artificial fill that unconformably overlie the bedrock formations. The bedrock consists of sedimentary formations with a regional dip of approximately two degrees to the east, ranging from Pennsylvanian/Permian to Cretaceous in age. Figure 3 presents a generalized cross section of the Rocky Flats area.

The subcropping strata become progressively older from east to west. West of RFETS, the sedimentary strata are exposed along the western limb of a monoclinal fold. The dip increases to the west as the layers abut against the Precambrian-aged crystalline rocks (EG&G, 1995a). The total thickness of the geologic section for the Paleozoic- and the Mesozoic-aged strata is approximately 13,000 feet.

The upper hydrostratigraphic unit (UHSU) at RFETS exists as an unconfined water-bearing unit. This upper water-bearing unit is primarily contained within the unconsolidated materials (Rocky Flats Alluvium, colluvium, and valley-fill alluvium), the subcropping Arapahoe Formation sandstones, and the upper weathered Arapahoe/Laramie Formation claystones/siltstones. Only the Rocky Flats Alluvium and the weathered bedrock exist in the area adjacent to Building 371.

2.2.1 Rocky Flats Alluvium

The Rocky Flats Alluvium is a Quaternary-aged pediment gravel deposited as a laterally coalescing alluvial fan deposit derived from Coal Creek Canyon. The Rocky Flats Alluvium consists of poorly sorted, angular to rounded cobbles, coarse-grained gravels, sands, and clays. The alluvial fan deposit thins from west to east, with thicknesses ranging from one to approximately 100 feet. In the area of Building 371, the Rocky Flats Alluvium is approximately 25 feet thick.

2.2.2 Arapahoe/Laramie Formation

The undifferentiated claystones of the Arapahoe/Laramie Formation are a Cretaceous-aged lithologic unit that essentially consists of structureless, olive-grey and yellowish-orange kaolonitic claystones (EG&G, 1995a), which underlies the Rocky Flats Alluvium. The upper part of this claystone is weathered, which forms part of the UHSU (along with the Rocky Flats Alluvium).

2.3 Climate

The climate of the area of Colorado in which RFETS is located is semi-arid and receives an average of approximately 15 inches of precipitation per year. On the average, daily summer temperatures at the plant site range from 55 to 85 degrees Fahrenheit and winter maximum temperatures range from 20 to 45 degrees Fahrenheit. Approximately 50 percent of the precipitation is received from snowfall during the winter and spring. Summer thunderstorms account for approximately 30 percent of the precipitation, with the remainder being received as light rain and snow during the fall. Approximately 85 inches of snow are deposited annually. Computed potential evapotranspiration is estimated to be approximately 39 inches per year (Fedors and Warner, 1993).

2.4 Building 371

Building 371 was constructed in an excavation that has removed the alluvium and weathered claystone beneath the building site. Drains were installed within the weathered claystone around the base of the building foundation. Compacted backfill has been installed in the area around the building's foundation. A sand filter pack has been installed around the drains to aid in ground-water collection.

3.0 MATHEMATICAL MODEL

The computer code selected for this modeling effort is the modular, three-dimensional finite-difference groundwater flow program of the U.S. Geological Survey (USGS) commonly referred to as MODFLOW (McDonald and Harbaugh, 1988).

The main criteria used for selection of MODFLOW for this project are:

1. The selected modeling code should be able to incorporate key hydrogeologic processes and accurately represent conditions known to occur at the site.
2. The selected modeling code should be able to satisfy the objectives of this study.
3. The selected modeling code should be verified using published equations and solutions.
4. The selected model should be complete and well-documented and preferably available in the public domain.
5. The selected modeling code should be practical and cost-effective in terms of actual applications as well as resolution of uncertainty.

The MODFLOW modeling code was selected based on each of the above criteria, given the following observations:

1. MODFLOW is a modular program with a wide-variety of packages available for simulating different hydrogeologic processes. The key hydrogeologic processes at the Building 371 area (areal recharge, drains, three-dimensional flow in saturated porous media) are simulated within various MODFLOW packages.
2. The primary objective of this project is to provide an estimate for the water level recovery after a catastrophic failure of the Building 371 drainage system. MODFLOW meets this objective by providing an initial set of drain-influenced water levels and a temporal simulation of the water level recovery for a grid network covering the area of interest.
3. MODFLOW has been successfully applied to many complex flow problems and is a widely used finite-difference groundwater flow model (Anderson and Woessner, 1992). Verification of MODFLOW has been performed by comparing the numerical results with analytical solutions to the partial differential equations describing ground-water flow through porous media (Anderson, 1993).
4. MODFLOW is a complete package for simulation of ground-water flow through porous media. No additional code is required for the flow computations. The MODFLOW code is documented in a comprehensive USGS publication (McDonald and Harbaugh, 1988) and the source code is available in the public domain.
5. Several modeling pre-processors and post-processors are available for aiding in MODFLOW input data development and output analysis. The MODFLOW code is widely available and is written in standard FORTRAN 77. It is easily implemented on any computer platform that has a FORTRAN 77 compiler. These factors provide for the practical and cost-effective

application of MODFLOW to this modeling effort. The structure and character of the MODFLOW input and output data sets provide for sufficient means for standard sensitivity analysis.

The Building 371 simulations use the standard, required MODFLOW modules for basic model input (subroutine BAS1) and conductance term calculation (subroutine BCF1). The strongly implicit procedure solver (subroutine SIP1) was used to solve the matrix of equations generated by the finite-difference approximations (McDonald and Harbaugh, 1988). The optional output control module was also used to provide better control of the format and frequency of the output generated by the simulation.

In addition to the modules discussed above, the recharge package (subroutine RCH1AL) and the drain package (subroutine DRN1AL) were used in this modeling exercise (McDonald and Harbaugh, 1988). The recharge package was included because areal recharge through precipitation is an important factor in ground-water flow at RFETS. The drain package was included to simulate the basement and sub-basement drainage system beneath Building 371.

4.0 MODEL IMPLEMENTATION

This section discusses the implementation of the ground-water flow simulation code for use in the Building 371 simulations. The implementation of the simulation involves developing input data for the code that reflect representative hydrogeologic conditions in the area around Building 371.

4.1 Implementation of the Conceptual Model

The conceptual hydrogeologic model is emulated by the computer code by designating input parameters and their associated values appropriate for the site. The Building 371 simulations focus on groundwater flow in the vicinity of Building 371, in both the alluvium and the weathered claystone. The simulation attempts to account for effects of the building's drainage system on ground-water levels around the building. The filter material around the drain is simulated using MODFLOW's drain conductance factor.

The compacted fill material around the building was not simulated. There is no data available on the hydraulic properties of this material and any values would be speculative. The hydraulic conductivity of this material, however, is probably greater than the weathered claystone. The hydraulic conductivity of the claystone would be the controlling factor for the transmissibility of ground water into the drains. The nexclusion of the compacted backfill in the simulations is a conservative simplification of the flow system, due to this ground-water flow control exhibited by the weathered claystone.

4.1.1 Model Domain

The model domain consists of both a spatial component and a time related domain. The spatial domain covers the region throughout which water levels will be computed by the computer simulation code. The temporal domain is the time throughout which the water levels are computed.

The model covers an areal extent that includes the northwest corner of the Industrial Area and includes all of Building 371. The model grid covers 600 feet by 940 feet (a total area of 564,000 ft^2). The model grid is oriented with the rows aligned along the east-west direction and the columns aligned along the north-south direction. The grid is implemented with a node spacing of 20 feet. A uniform grid spacing was utilized to increase the computational efficiency of the simulations. Figures 4 and 5 present the model grids for the upper and lower layers of the simulations, including boundary conditions.

The model has two layers, representing the alluvium (top layer) and the weathered claystone (bottom layer). The upper layer is simulated as an unconfined layer with the lower layer simulated as an unconfined/confined layer. An unconfined/confined layer is modeled as a confined layer provided the water levels in the layer are above the top of the layer. Once the simulated water levels drop below the top of the layer, it is simulated as an unconfined system. The lower layer was designated as an unconfined/confined layer because MODFLOW only allows the top layer to be designated as unconfined.

The total dimensions of the grid were determined by adding a distance of influence to the dimensions of the building. The distance of influence is the distance from the drain to a point where there is no drawdown from the drain. This distance was calculated using a radius of influence estimation technique for a pumping well contained in Harlan and others (1989).

The simulation of this model involved simulations in steady state and transient conditions. The steady state simulation was run to obtain a ground-water flow field that included the effects of the building's drainage system. This drain-affected flow field was then used as the initial water levels for the transient runs.

The model was run in transient mode to obtain the recovery of the water levels after a hypothesized catastrophic drain failure. The temporal domain of the transient model was run using 15 day time steps for approximately 10 years.

4.2 Simulated Processes

Some of the factors affecting ground-water flow in the geologic media around Building 371 are not incorporated within the subsurface flow system itself. These factors are external processes that have a direct influence on the ground-water flow system. The two most significant external processes included in the Building 371 simulations are areal recharge and the building's drainage system. These two factors have an important influence on the head elevations in the vicinity of Building 371 and thus, affect the subsequent flow pattern.

4.2.1 Areal Recharge

Percolation of precipitation through the unsaturated zone to the water table can account for significant recharge to the subsurface flow system. There are several factors that influence this process. The primary factor that can restrict the amount of infiltrating water available to recharge the ground-water system is loss through evapotranspiration. The process of evapotranspiration may remove water held in the unsaturated zone before it can recharge the saturated zone. The potential evapotranspiration at RFETS has been calculated to be approximately 39 inches of water per year (Fedors and Warner, 1993). This value is more than twice the annual precipitation at RFETS. This demonstrates the great potential for water loss through evapotranspiration.

Although MODFLOW includes a module to simulate water loss through evapotranspiration, a much simpler and common approach uses the net recharge to the ground-water system. By using the concept of net recharge, one does not have to consider actual evapotranspiration rates, but rather the estimation of the amount of remaining water that enters the ground-water system. In MODFLOW this can be accomplished by using the recharge package, which adds an areally distributed recharge value (feet/day/unit area) into the flow calculations.

4.2.2 Drains

The purpose of the drain system is to lower the water table around Building 371 to prevent basement flooding. The drainage system beneath Building 371 consists of two systems set at different elevation levels. The sub-basement drain is installed within the claystone at an elevation of approximately 5967 feet and the basement drain system is also set into the claystone at an approximate elevation of 5983 feet. The engineering plan for the drainage system is presented in Figure 6.

4.4 Modeling Parameters

This section reviews the values of input parameters used for the Building 371 simulations. Where available, RFETS field measured values were used. Appropriate literature values were used as guidance when field data were unavailable or had significant uncertainty. Some parameters had neither field data nor appropriate literature values. In this case, professional judgment was used in determining the input value.

4.4.1 Hydraulic Conductivity

Hydraulic conductivity is a parameter that enters directly into the flux calculations within MODFLOW. Field and laboratory measured values are available for both the Rocky Flats Alluvium and the Arapahoe/Laramie Formation bedrock. A summary of the hydraulic conductivity values determined for geologic materials at RFETS has been summarized in EG&G (1995b). For both the Rocky Flats Alluvium and the claystone layers, the geometric mean of the available values was used as the hydraulic conductivity for the model. These values are 0.44 feet/day for the Rocky Flats Alluvium and 0.06 feet/day for the weathered claystone bedrock.

4.4.2 Specific Yield

MODFLOW uses values of specific yield to determine the head change in a cell based on the volumetric water flux into and out of the cell. Although estimates of specific yield are available from some of the multi-well pumping tests conducted at RFETS, these values are somewhat problematic. Because of the uncertainty of these values, representative values of 0.1 and 0.05 were adopted for the specific yield for the alluvium and claystone, respectively. These values are consistent with that estimated by Hurr (1976) and lies within the range of values expected for the type of geologic materials being considered (clay, silt, and sand) (Anderson and Woessner, 1992).

4.4.3 Areal Recharge

This model uses a net recharge approach in simulating recharge from precipitation. Previous modeling studies at RFETS indicate that the recharge is approximately 2 inches per year (4.57×10^{-4} feet/day). This value for recharge was applied evenly over the surface of the model, except for the area in the upper layer that outlines the footprint of the building for the transient model. Recharge was only applied to the uppermost layer of the model, simulating percolation of water from the surface into the UHSU.

4.4.4 Geologic Layering

The Building 371 model was divided into two layers, with the upper layer representing the alluvium (layer 1) and the bottom layer presenting the weathered claystone bedrock (layer 2). The bottom of layer 1 was set using an average value of the bottom of the alluvium (5987 feet) in the vicinity of Building 371. Since it was only necessary to simulate the thickness of the weathered claystone bedrock that was affected by the drains, the bottom of the lower layer was arbitrarily set at 5965 feet, which is two feet below the elevation of the sub-basement drains.

4.4.5 Initial Water Levels

As a starting point for the simulations an initial ground-water level grid is input into the MODFLOW model. For the steady state simulation, a constant value of 6007 feet was used throughout the model domain for both layers as the initial water level. This value represents the approximate average value obtained from well P119389, which is near Building 371. The initial water levels for the transient model were the computed water levels for the steady state model, which reflects the effect of the drainage system on the flow system.

4.4.6 Boundary Conditions

As part of the mathematical definition of the flow model, the conditions at the outer boundary of the model grid must be specified. In MODFLOW these boundary conditions are typically either no-flow or constant head. Both of these types of boundaries, in addition to drain cells, were used in the Building 371 simulations. Figures 4 and 5 show the various boundary conditions used in the modeling exercises.

4.4.6.1 Constant Heads

Constant head boundaries are composed of grid cells for which the head does not change during the simulation. The edges of the model were set up as constant heads with a value of 6007 feet. The outer boundaries of the model (at which the cells are constant head cells) were located at such a distance from the Building 371 drainage system that the influence of the boundary conditions should be minimal.

4.4.6.2 Drains

The basic configuration of the two drain systems is preserved, but is simplified to fit within the constraints of a rectangular gridded representation. The sub-basement drains have been assigned an elevation of 5967 feet and the basement drains an elevation of 5987 feet. A conductance term, describing the head loss between the drain and undisturbed water levels, was set at a relatively great value (6.0 ft/day). This large value represents the drain filter material and the degree of connection of the drain to the surrounding formation. A large value of 6.0 ft/day was selected after trial and error to obtain water levels in drain cells that are approximately equal to the elevation of the drain cell. The drain cells were not used in the transient simulation, since the simulation examined the effects of a failure of the drains.

4.4.6.3 No Flow Boundaries

No-flow boundaries are composed of grid cells that are not active in the flow system. Because these cells are not incorporated into the flow system, there is no water flux into or out of this type of cell. Since this subsurface volume occupied by the building does not have any porous media present (due to excavation for the building), the cells within the simplified building excavation were inactivated and effectively designated as no-flow cells. Water levels are not calculated for these cells. Recharge applied to these cells is not introduced into the model. This is considered a reasonable representation of the building volume within the alluvium and claystone. Figures 7 and 8 present the inactive areas present within layers 1 and 2, respectively.

5.0 MODELING APPROACH

The modeling approach involved the construction of a model representative of the hydrogeologic system in the vicinity of Building 371. A steady state model was run to obtain the initial water levels for the transient run. The resulting steady state run included the effects of the drainage system of the ground-water flow field, showing drawdown of the water levels by the basement and sub-basement drains. The resulting flow field was then used as the initial water levels for the transient simulation. The transient model was run without drains, with some cells in the alluvium and claystone inactivated to simulate the subsurface volume of the building. This transient simulation would effectively simulate a failure of the drainage system. Water levels were allowed to recover until they reached the value of the initial steady state water level (6007 feet).

Since the model did not attempt to simulate an extremely detailed and realistic model of the area around Building 371, no calibration was necessary to match observed water levels. The goal of this modeling effort was to provide water level recovery rates using representative values of hydraulic parameters. However, some parameters were modified to produce a valid representation of the hydrogeology in the vicinity of Building 371. The time step length was modified to obtain a mass balanced model. Calibration was, however, performed in the value of the drain conductance term. The term was varied in order to obtain water levels in drain cells at the approximate elevation of the drain cells.

6.0 MODELING RESULTS

Initially, a steady state model was run to obtain the subsurface flow field as affected by the drainage system of Building 371. Using these drain-affected water levels as the initial ground-water flow field, a transient simulation was performed. This transient simulation allowed water levels to rise with time. The modeling results show that the time for water levels to recover to static level for both layers is less than 3 years, using representative hydrogeologic parameter values.

6.1 Steady State Simulation

The steady state model was run to obtain the initial drain-modified water levels for the transient recovery model. Profiles of the drain-effected water levels in layer 1 and 2 are presented in Figure 9. These profiles are taken along the east-west centerline of the model (row 16) and show the drawdown induced by the drain system on the static water level of 6007 feet. Maps of the results of the steady state modeling are presented in Figures 10 and 11.

Examination of these figures reveals the presence of a steep gradient toward the center of the building, induced by the drainage system. When examining the water level plots and maps, the reader should remember that while the model contains two layers, it simulates a single hydrogeologic system. Water levels are fairly similar in both layers, outside of a desaturated area in the central area occupied by the building. Downward gradients in the ground-water flow field have been induced adjacent the building by the drainage system. This downward gradient, in general, causes groundwater to flow downward from both layers into the drains.

6.2 Transient Simulation

The transient runs indicate that, using representative hydrogeologic parameters, the time for complete water level recovery to static water levels (6007 feet) is less than 3 years for both layers (2.55 years for layer 1 and 2.9 years for layer 2). The transient water level recovery plots for layers 1 and 2 are presented in Figure 12. The water levels for these plots are obtained from the north central edge of the building.

Examination of these plots reveals that the initial water level recovery, as expected, proceeds at an initially rapid rate and decreases with time. Within the first year, the water level recovers 14.01 feet and 31.58 feet for layers 1 and 2, respectively. One month after drain failure, water levels have risen 1.93 feet in layer 1 and 6.04 feet in layer 2. Figure 13 presents the water level recovery during the first year in layers 1 and 2 for the central node along the northern edge of the building.

Water levels for layer 1 (outside of the central inactive zone simulating the building excavation) are somewhat similar to those of layer 2. This is to be expected since both layers simulate a single hydrogeologic system. Layer 2 water levels are lower than those of layer 1, indicating a slight downward gradient throughout most of the recovery time.

6.3 Sensitivity Analysis

From the modeling results, it became obvious that the time for water level recovery may be controlled by the claystone. Because of this a sensitivity analysis was performed in which the hydraulic conductivity value of the claystone was varied. The recovery time for these sensitivity analysis runs were compared to that of the base case.

Two sensitivity analysis runs were made by modification of the hydraulic conductivity value of the claystone. The hydraulic conductivity value for the claystone was changed to 0.12 ft/day and 0.18 ft/day (2 and 3 times the initial value of hydraulic conductivity for the claystone).

Figures 14 and 15 present the recovery curves for both layers from the central cell of the northern edge of the building for the two sensitivity runs. Using a hydraulic conductivity of 0.12 ft/day results in complete water level recovery to static conditions within 2.6 years with first-year recoveries of 15.06 feet and 34.47 feet for layers 1 and 2, respectively. Using a hydraulic conductivity of 0.18 ft/day resulted in complete water level recovery to static conditions in approximately 2.6 years with first-year water level recoveries of 15.87 feet and 35.81 feet for layers 1 and 2, respectively.

Examination of the results of these runs indicates that the modeling results are not significantly affected by the hydraulic conductivity value for the claystone (within realistic values). Modifications of the claystone's hydraulic conductivity slightly decreases the recovery time and slightly increases the amount of recovery, but water levels still recovery rather quickly.

6.4 Limitations

There are limitations inherent in this modeling exercise, as there are in all simulations. Modeling does not simulate reality exactly. It is impossible to account for all natural processes in a simulation, due to lack of current scientific understanding and computational limitations. Models should be thought of as "cartoons of reality".

MODFLOW does not simulate fracture flow systems. It can only simulate porous media ground-water systems. An approach called "equivalent porous medium" can be used. This approach replaces the primary and secondary porosity and hydraulic conductivity with effective hydraulic parameter values which produce a flow pattern similar to that displayed by fractured media (Anderson and Woessner, 1992).

7.0 SUMMARY AND CONCLUSIONS

Using representative hydrogeologic parameters, a steady state and transient model was constructed to simulate the drainage system of Building 371 and the effects of a catastrophic failure of this drainage system from an adjacent seismic event. The steady state model was run to obtain initial water levels for the transient run and included the effects of the drainage system on the ground-water flow field. A transient model was run without the drains, to simulate the recovery of the water levels to static conditions after a catastrophic drain failure.

Results indicate that it would take less than 3 years for complete recovery of the water level conditions to static conditions, with 14.01 feet of recovery for layer 1 and 31.58 feet of recovery for layer 2 within the first year after drain failure. Water level recovery rates are relatively rapid initially and decrease with time.

Sensitivity analyses indicate that the time for water level recovery does not appear to be greatly affected by the hydraulic conductivity of the claystone. Increasing the value of the claystone's hydraulic conductivity does not significantly decrease the time for water level recovery. Increases in the claystone's hydraulic conductivity, however, does increase the amount of recovery during a given time period.

It is apparent that, using the assumptions of this modeling exercise, water levels will recover fairly rapidly after a hypothesized drain failure. Proper planning and rapid response to a potential seismic event causing drain failure are necessary to ensure building safety. Preparedness measures, such as an array of idle pumping wells, may be considered for immediate implementation after drain failure. This could enable work crews to repair the drains at a somewhat less hectic pace induced by rising water levels.

While not simulated explicitly, some comments can be made on partial failure of the drainage system. Because the sub-basement drainage system is the lowest in elevation of the two systems, it appears to have the greatest impact on the flow field. Single failure of the basement drainage system, while presumably taxing the capacities of the sub-basement drains, could result in some water rise around the edges of the building, mostly in the alluvium. The sub-basement drains could be able to retain the low water levels around the building. Failure of the sub-basement drains could result in an approximate 16-foot water level rise over time. This is based on the assumption that the water levels will only rise from the sub-basement drain elevation to the elevation of the basement drains.

8.0 REFERENCES

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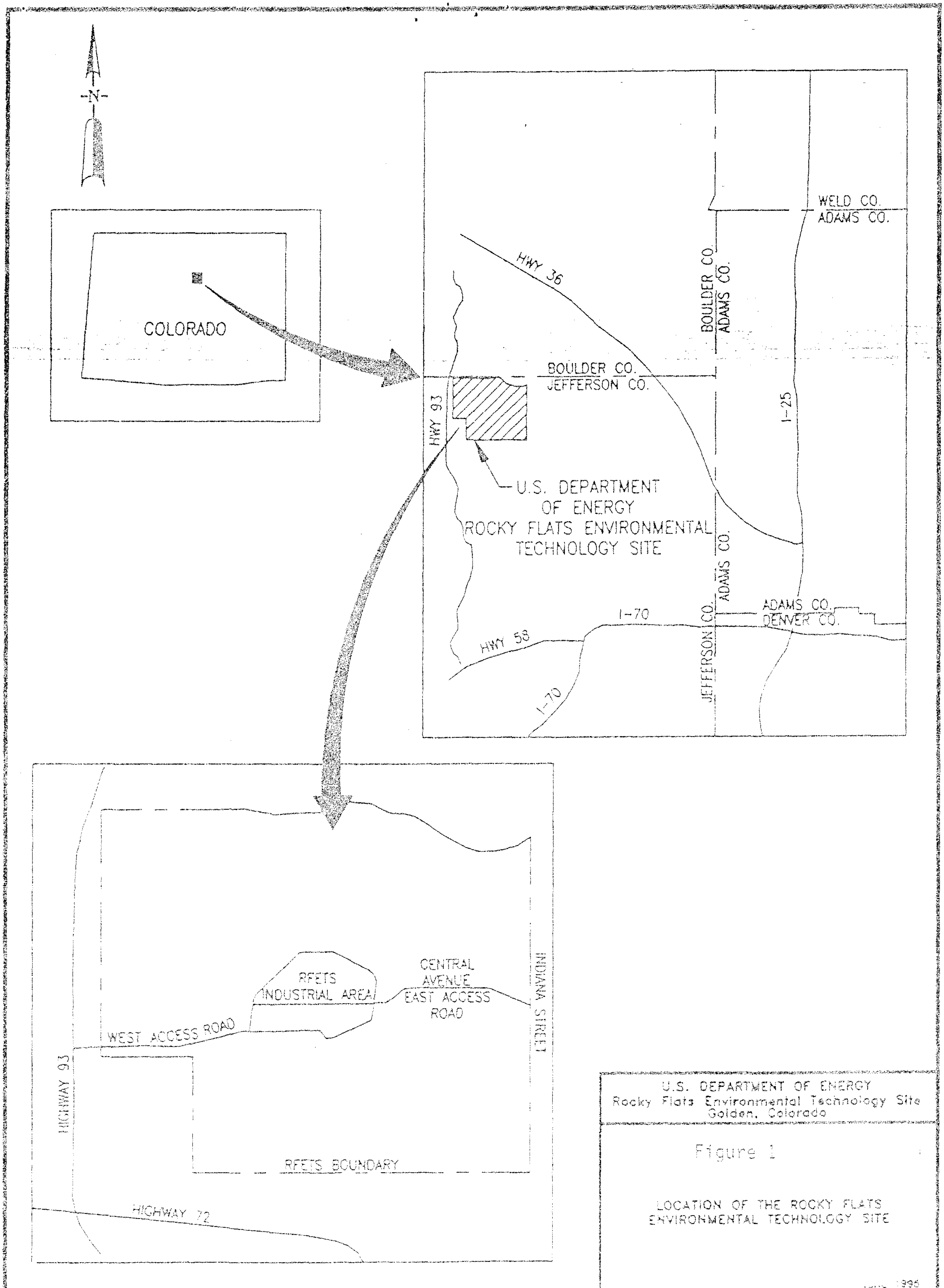
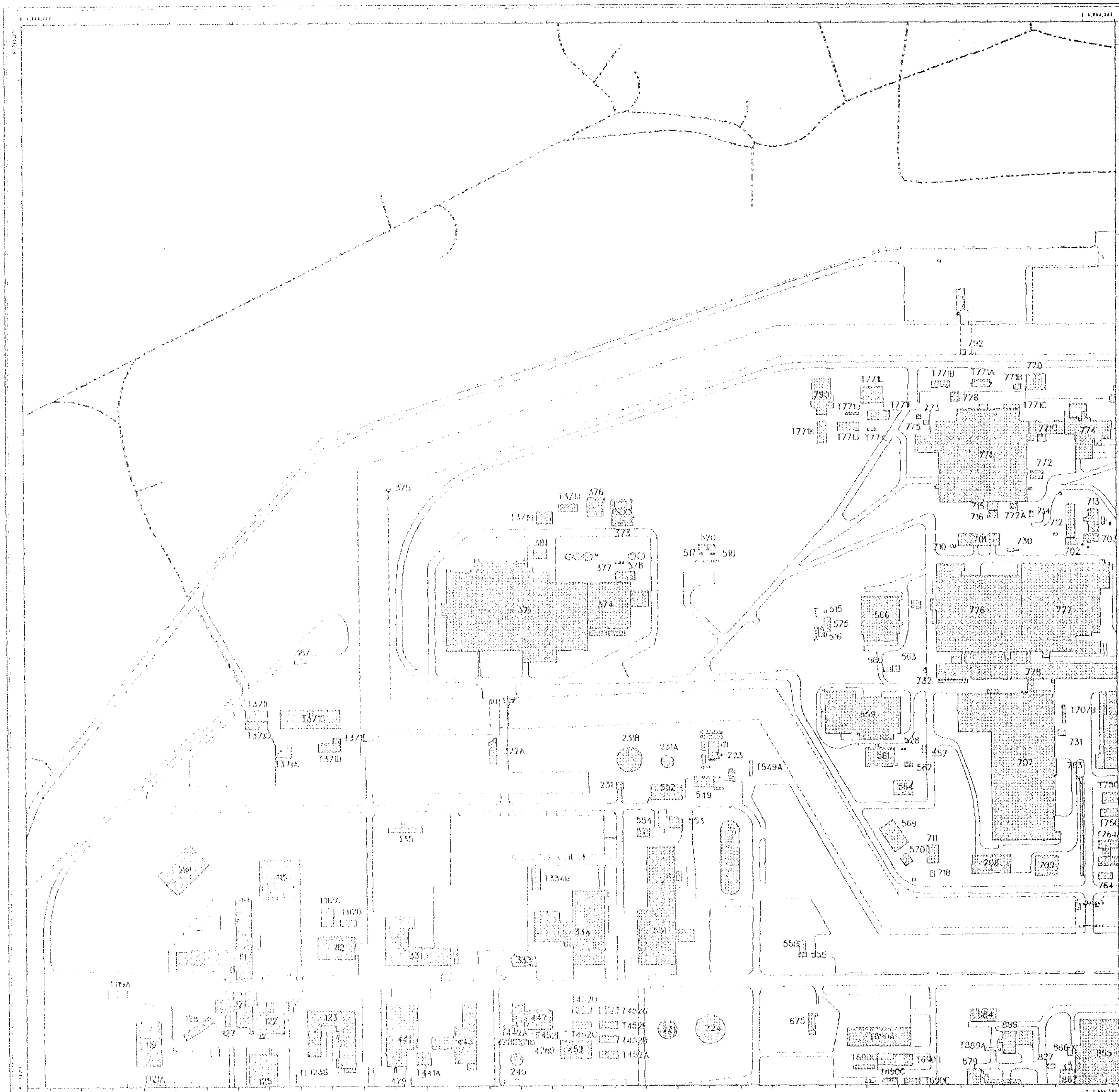


U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado

Figure 1

LOCATION OF THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE



Building 371 Location Map

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, roads, and fences provided by
Facilities Engr.,
EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by
USGS - (date unknown)

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Figure 2

Scale = 1 : 5400
1 inch represents approximately 467.5 feet

100 0 200 400 Ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

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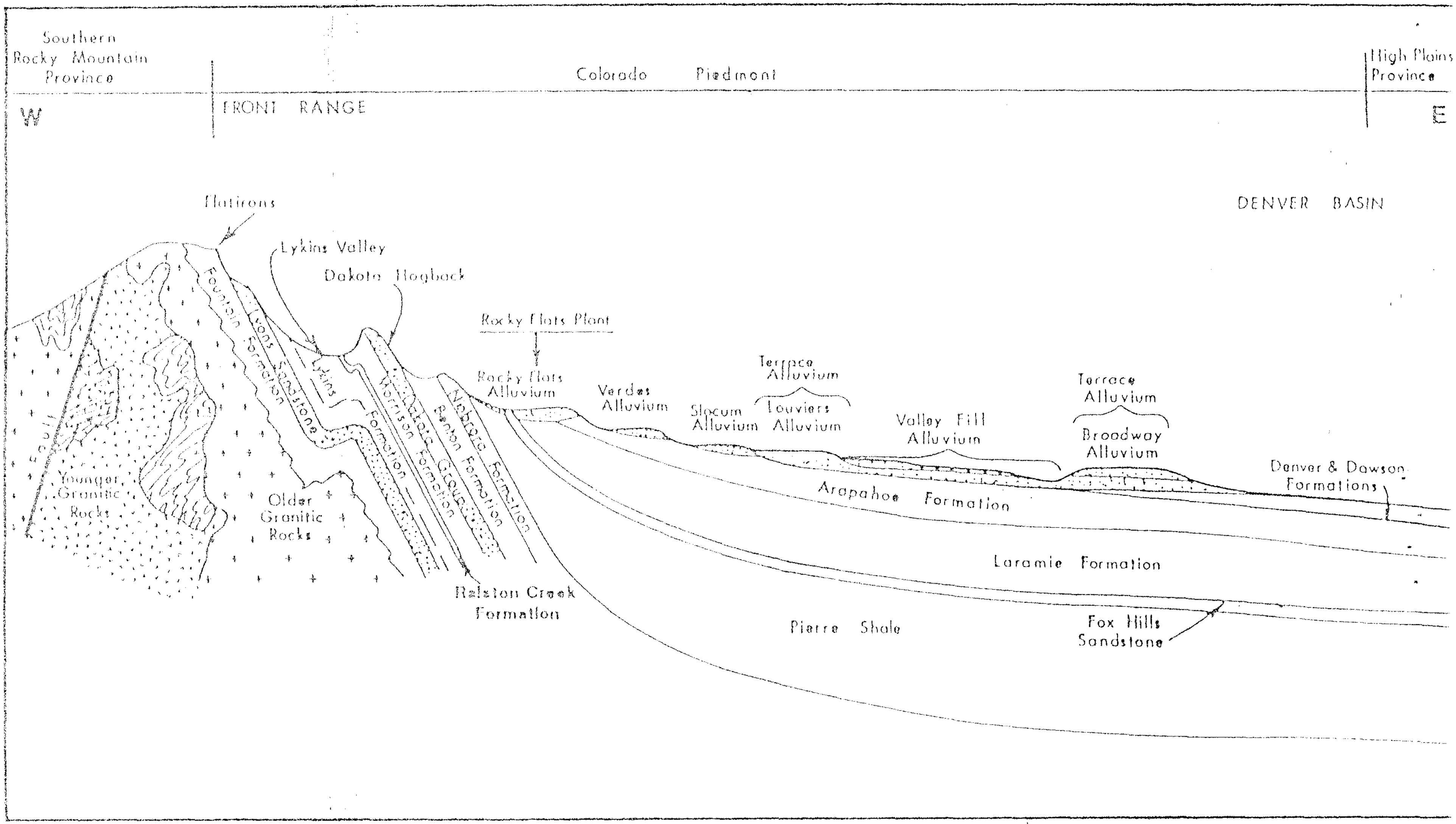
MAP ID: bkkg-371

August 20, 1996

/home/515182/projects/w-belcher/induet-base.aml



(after: Boulder County Planning Commission, 1983 and Scott, 1960)

Not To Scal

Figure 3

Generalized Geologic Cross Section of the Rocky Flats Area

Figure 4

Layer 1 Model Grid

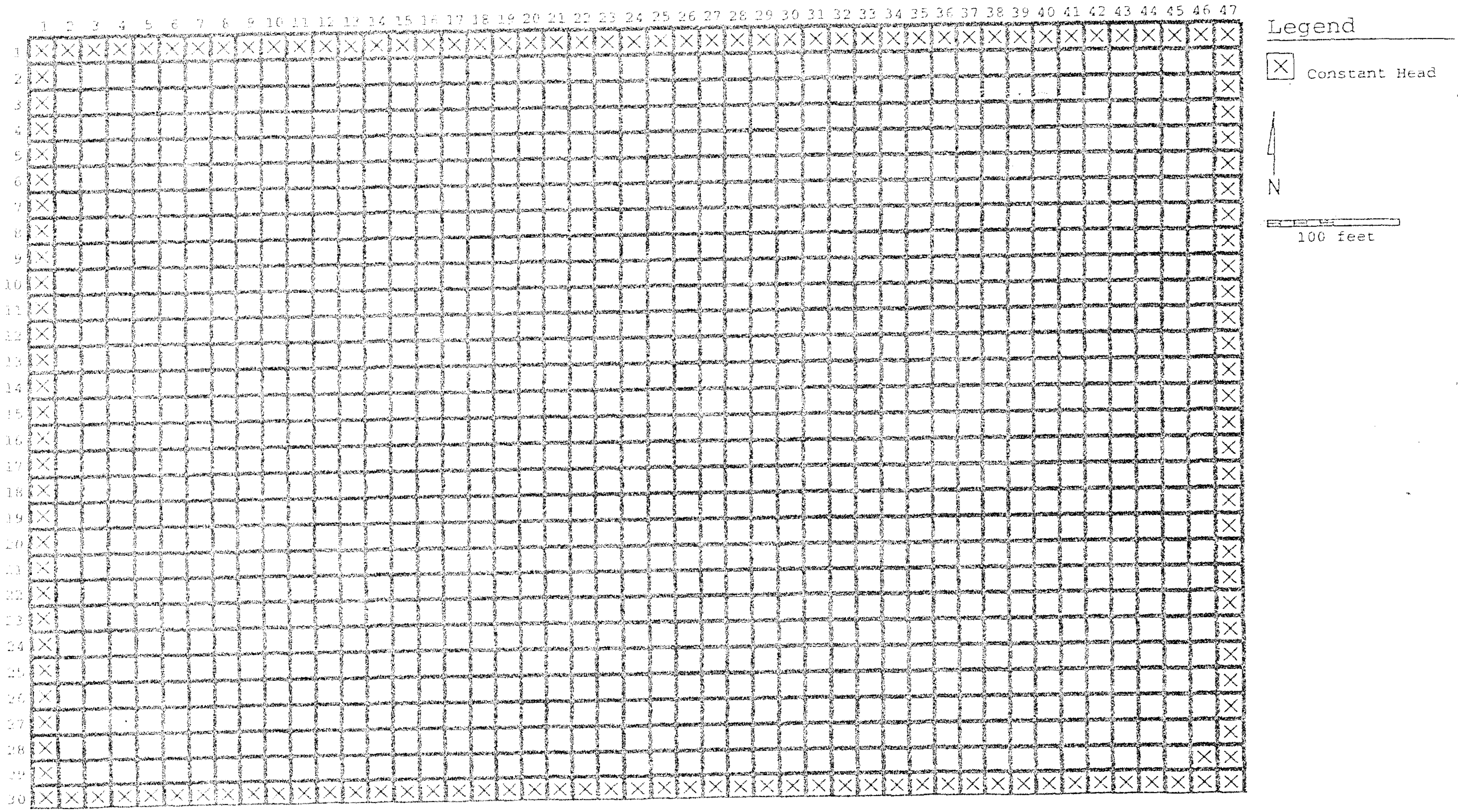


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Figure 5

Layer 2 Model Grid

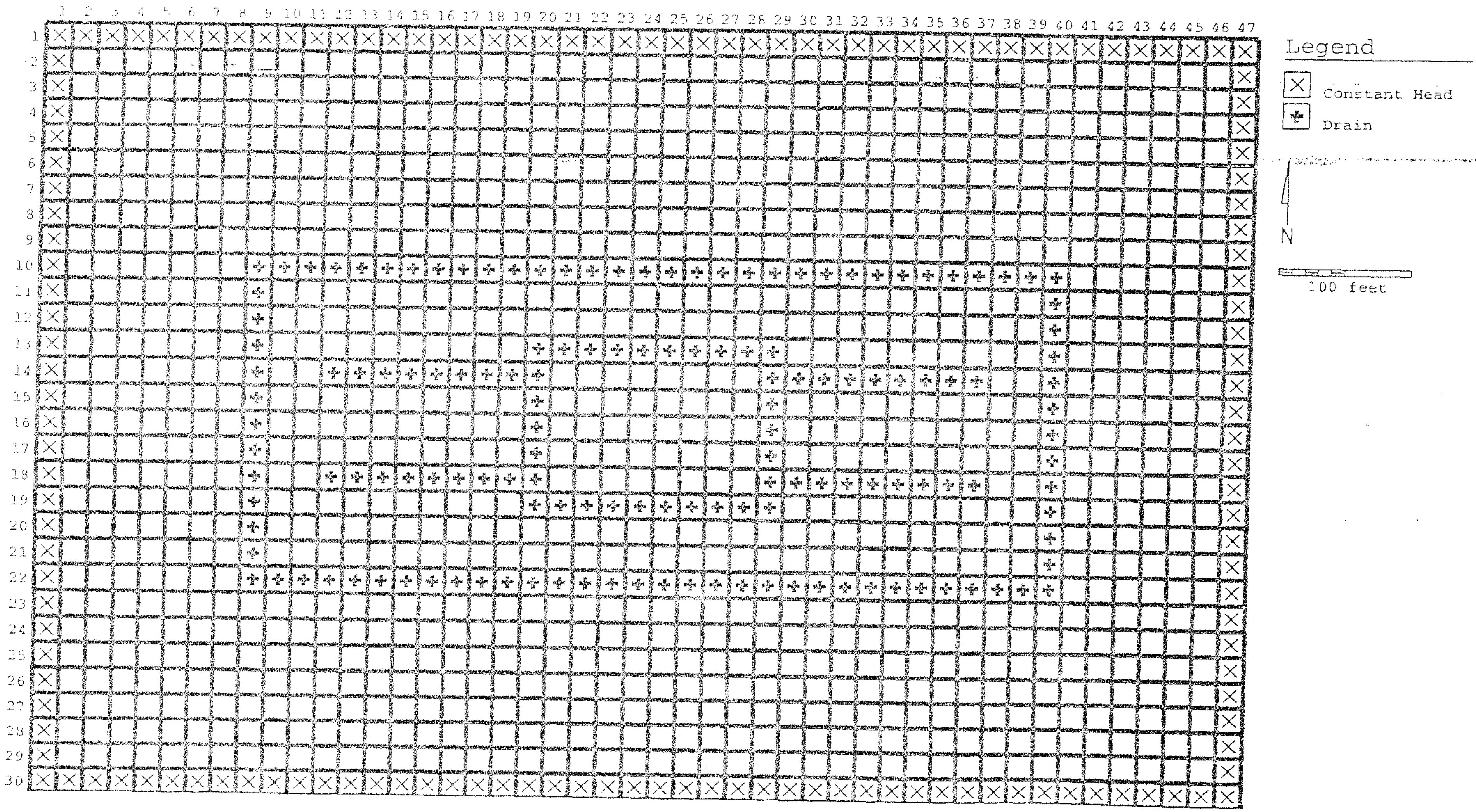

Figure 6

Building 371 Drainage System

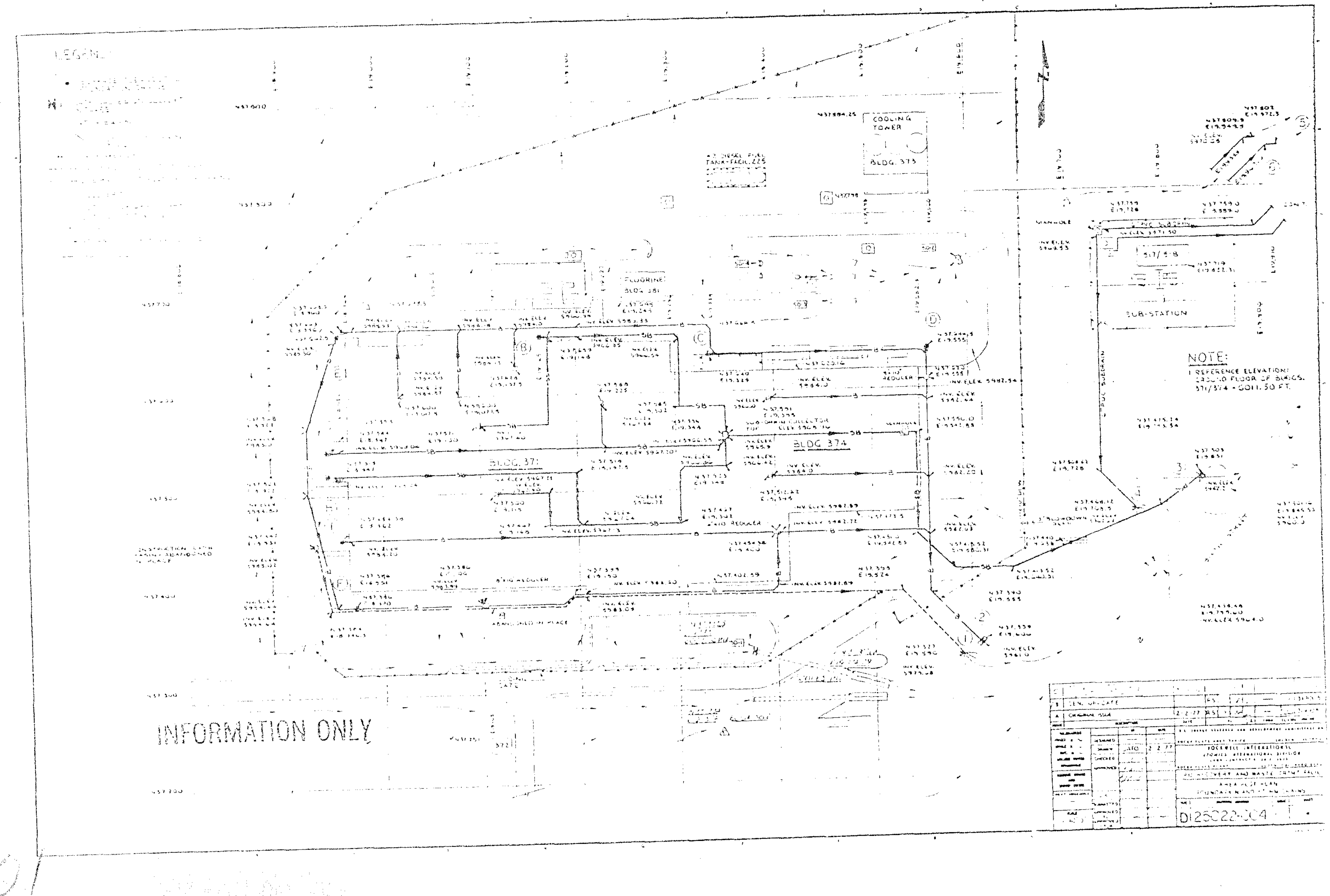

Figure 7

Inactive Cells for Transient Layer 1

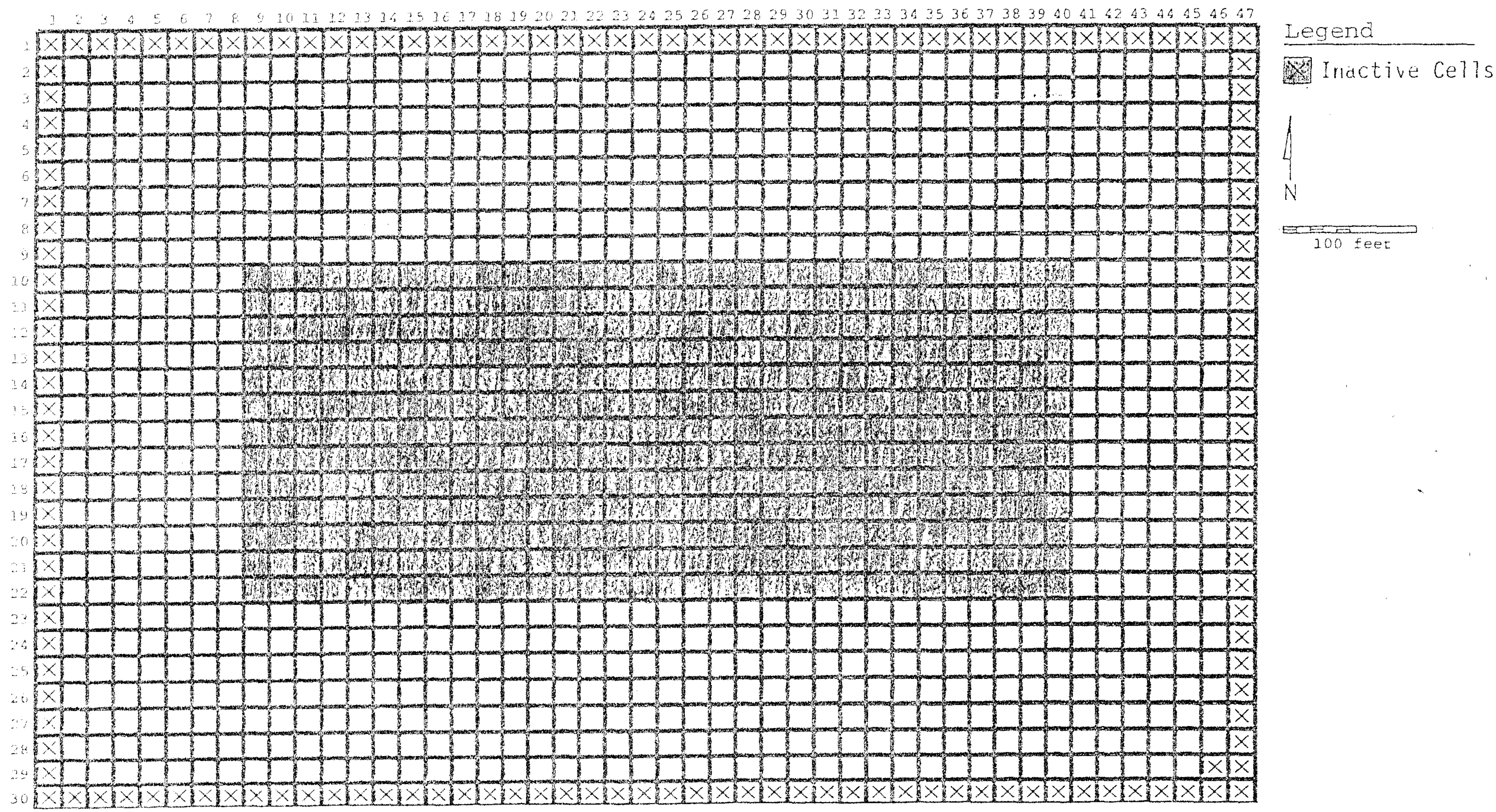

Figure 8

Inactive Cells for Transient Layer 2

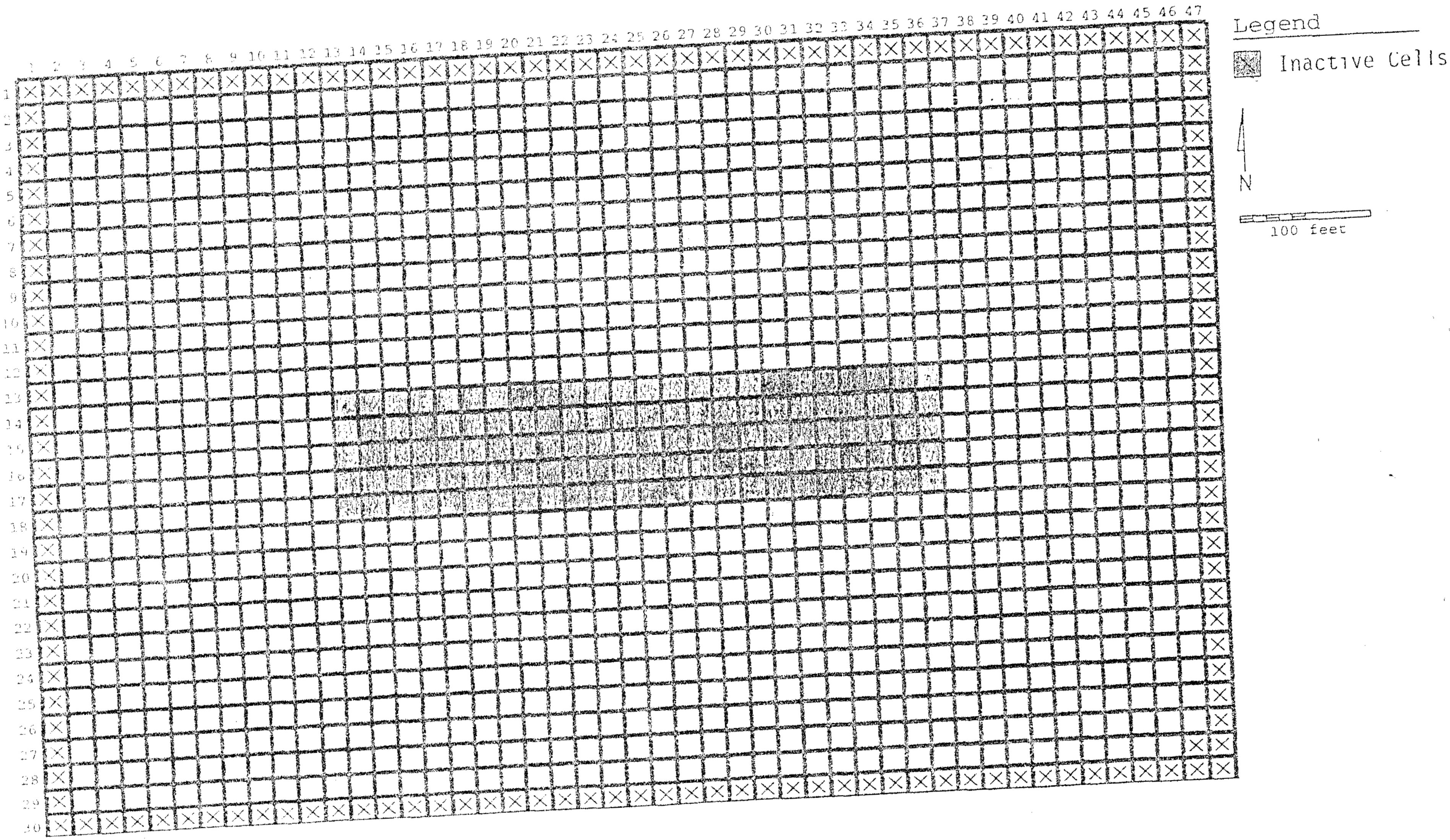

Figure 9
Building 371 Simulation
Steady-State Water Level Profile for Layer 1 and 2

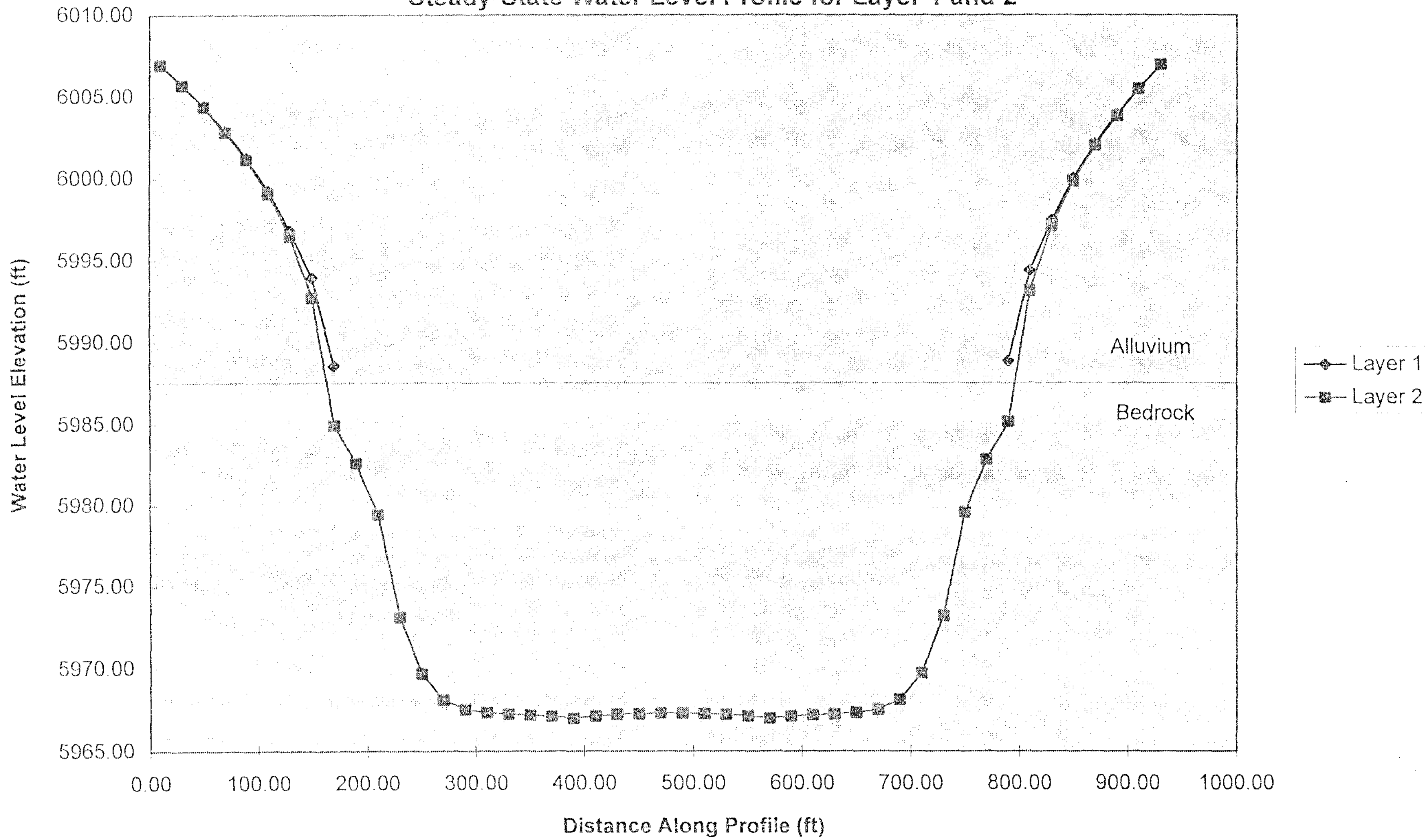

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Figure 10
Building 371 Simulation
Steady-State Water Level Map for Layer 1
(contour interval = 2 feet)

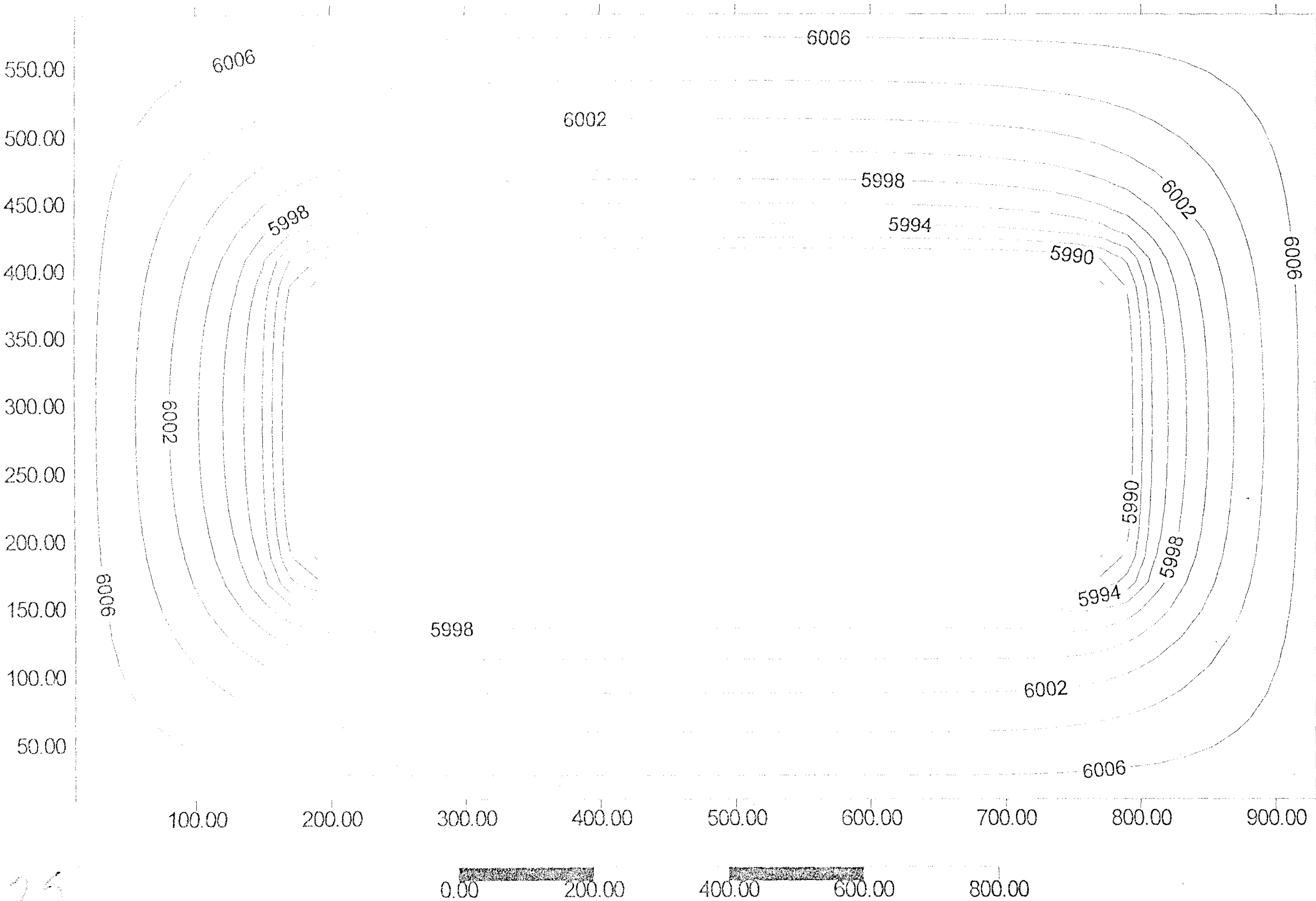

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Figure 11
Building 371 Simulation
Steady-State Water level Map for Layer 2
(contour interval = 4 feet)

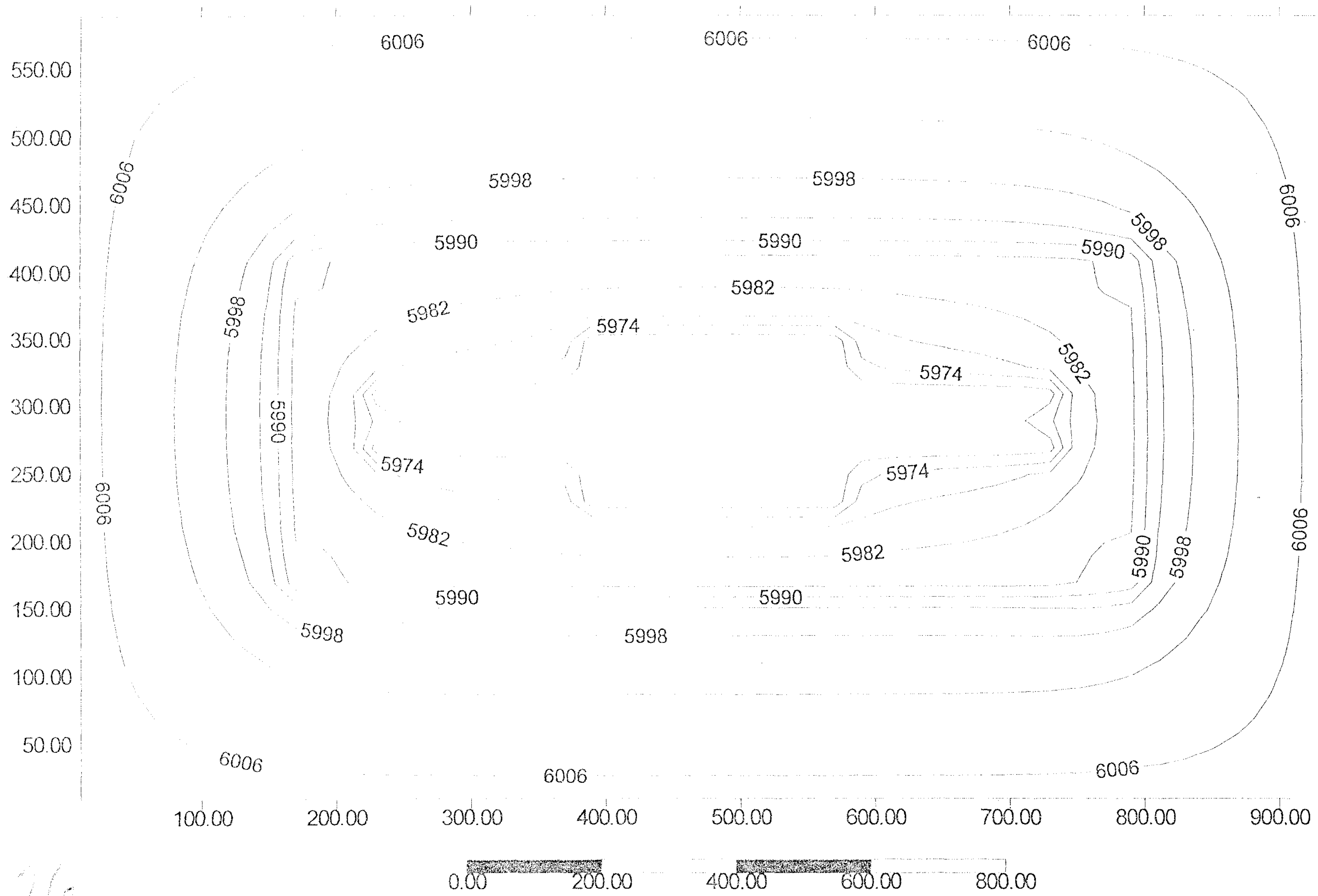

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Figure 12
Building 371 Simulation
Transient Water Level Recovery for Layers 1 and 2

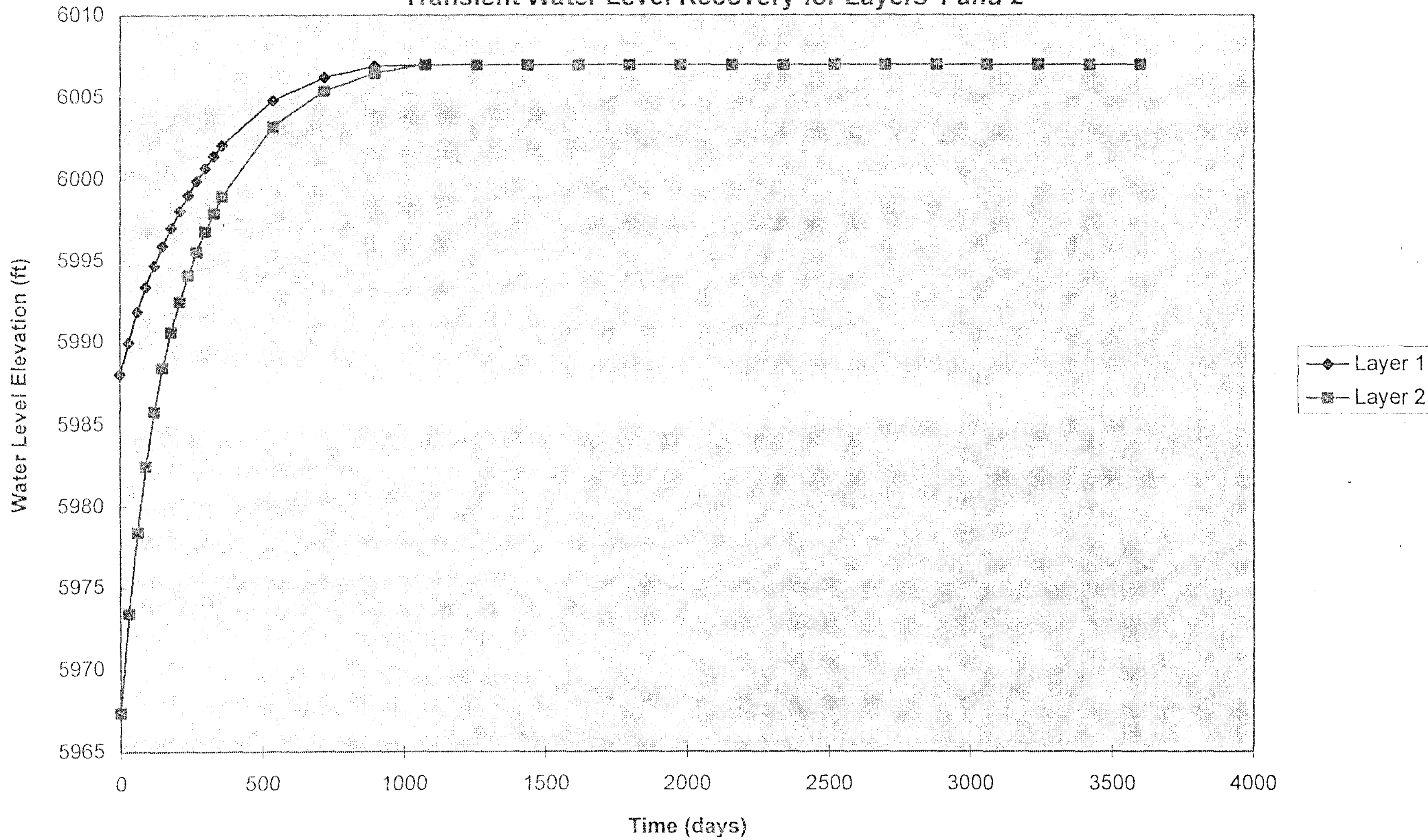

Figure 13
Building 371 Simulation
First Year Transient Water Level Recovery for Layers 1 and 2

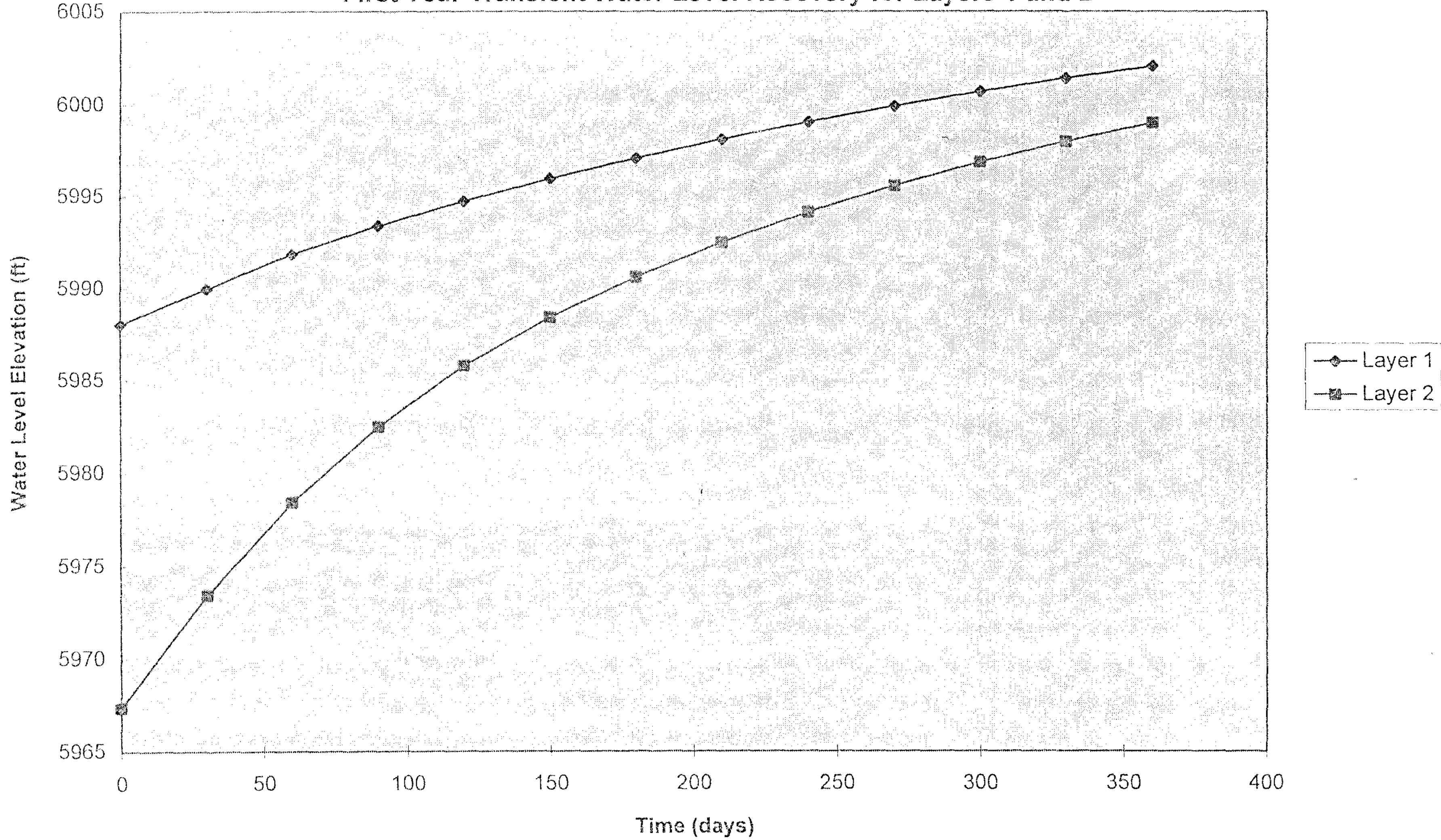

Figure 14
Building 371 Simulation
Transient Water Level Recovery for Layers 1 and 2 with Claystone K = 0.12 ft/day

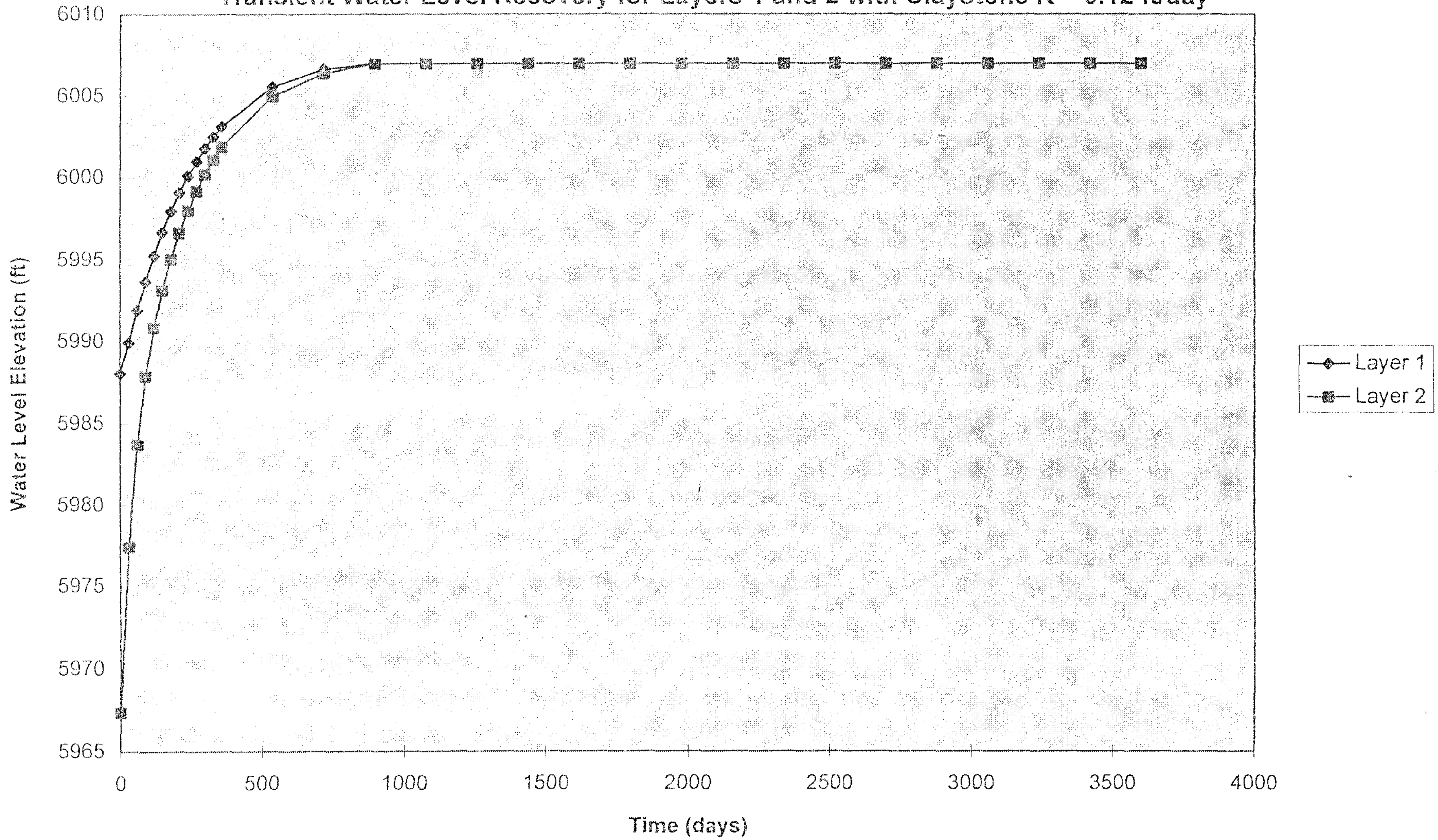

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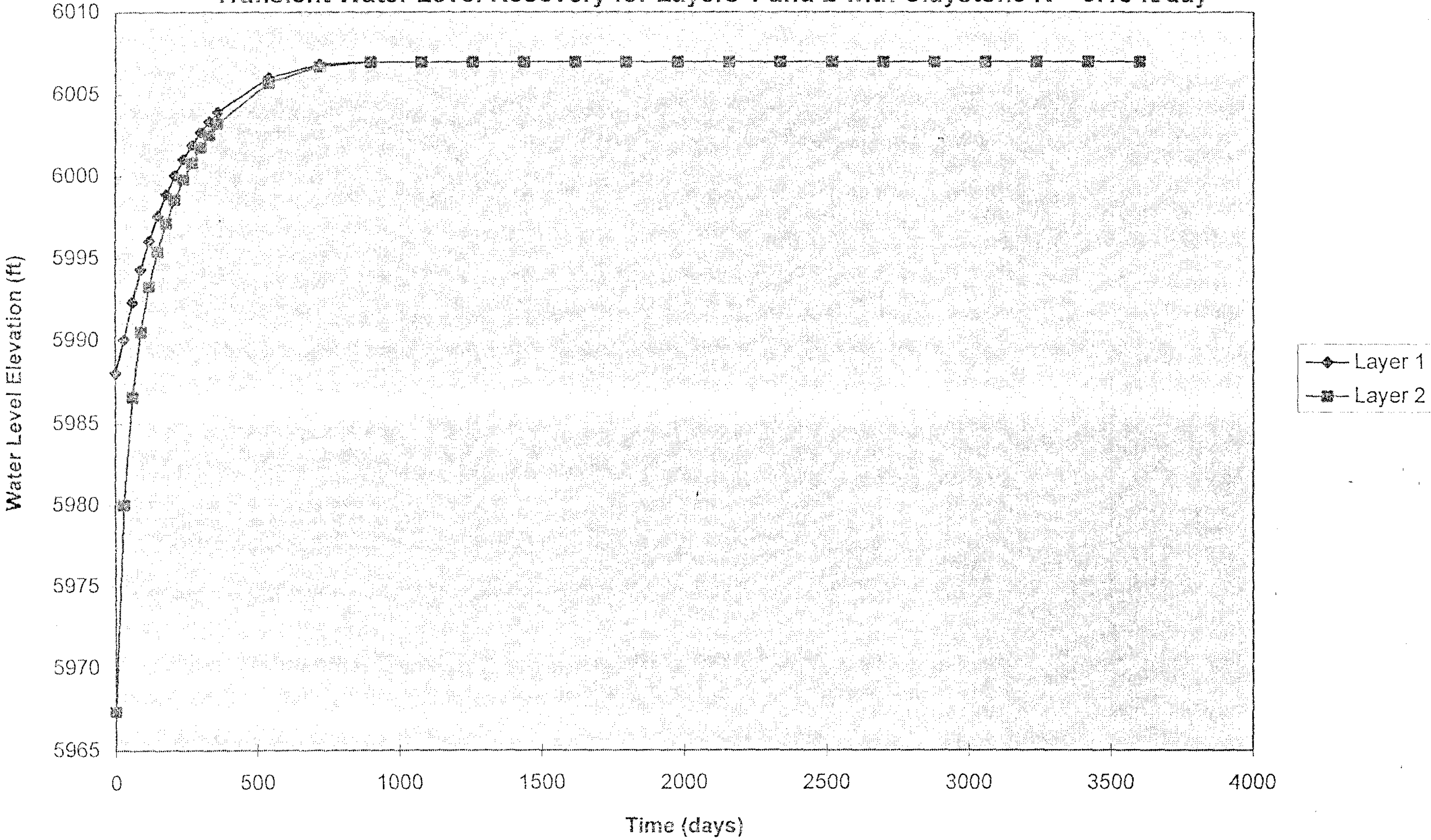
Figure 15
Building 371 Simulation
Transient Water Level Recovery for Layers 1 and 2 with Claystone K = 0.18 ft/day



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